Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

General Comments

Our review of the Navy's Memo did not show sufficient data to support the report's conclusion that the Westbay sampling system successfully isolated specific subsurface sampling zones from each other at RHMW11 as discussed in the report's six areas listed below.

1. Evaluation of the grouted 10-inch and 5-inch blank casing;

2. Manufacturer's certification of packers;

3. Field packer inflation records;

4. Vertical pressure profiles;

5. Vertical temperature profiles; and,

6. Pneumatic testing of multiple zones within monitoring well RHMW11.

Our specific comments are below.

Response to General Comment:

The Westbay evaluation is based on multiple lines of evidence. Responses to the six specific areas commented on are provided below. In addition, general information on testing the borehole annulus seals, the Westbay packers, and evaluating effective borehole packer seals should also be considered as described in Items 1 – 3 in this response.

1. General comments on testing borehole annulus seals (packers or backfill or other seal method)

- A borehole is not a controlled laboratory environment.
- The function of a borehole annulus seal is to prevent the annulus from acting as a vertical preferential pathway between adjacent zones in a borehole. This can be referred to as an effective annulus seal.
- If there is a naturally occurring hydraulic connection between adjacent zones in the formation beyond the annulus, then an annulus seal should not inhibit this connection.
- The hydraulic properties of the borehole in the vicinity of an annulus seal affect the response of hydraulic tests of the annulus seal. Therefore hydraulic testing of borehole annulus seals is affected by the properties of the formation.
- It is not possible with a hydraulic test to differentiate between naturally occurring vertical connection and annulus seal behavior. Therefore, assessment of annulus seals in bedrock boreholes is best accomplished with a multiple lines of evidence approach where independent sources of corroborating information are used to support a conclusion regarding performance. With this approach, each line of evidence might not provide conclusive proof of annulus seal performance. However, repeated indication of the same conclusion from multiple independent lines of evidence can lead to reasonable conclusions about the annular seal performance.
- It is worth noting that multilevel completions offer superior capability to assess annulus seal performance with hydraulic tests and hydraulic performance by providing measurement access to either side of an annulus seal, compared to single-point borehole completions, where no such capability exists.

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

2. General Comments on Westbay Packers

- Packers are designed to perform according to their specifications, including differential pressure capability and borehole diameter compatibility. The design capability is confirmed by rigorous bench testing.
- Packers are manufactured according to strict quality control specifications to provide repeatable performance.
- Packer elements are made of a tough elastomer material which conforms to uneven surfaces in a manner similar to that of an 'impression packer' used for inspecting minor details of borehole walls.
- In Westbay's experience with packers retrieved from boreholes after long duration operation (sometimes 20+ years), visual inspection of the retrieved the elements shows that the contact/seal against the borehole wall had been consistently maintained. In fact, adhesion of packer elements to borehole walls is sometimes an issue that requires attention during retrieval of a Westbay completion.

3. General comments on evaluating effective borehole packer seals

a. Manufacturer's Certificate - confirms that the packer passed the rigorous manufacturing tests of functionality and quality. Thus one can conclude that the packer is capable of providing a good annulus seal.

b. Completion Design for Quality Assurance - careful selection of the borehole location is made for packer position. Retrieved core samples, geophysical logs, video logs, etc. are used to confirm that the selected borehole location is suitable for creation of an annulus seal.

- On occasion, multiple (redundant) packers can be included in the completion design between primary monitoring zones to take advantage of available suitable borehole packer seal locations.
- Careful positioning of the packer at the intended seal location. This positioning is documented by means of the Westbay Installation Log.

c. Packer Inflation Records - confirm the correct inflation of the packer based on standard measured parameters and expected performance in the borehole diameter conditions. Thus one can conclude that the packer inflated correctly. Westbay bench testing of the same packer model in a controlled environment shows that a correctly inflated packer is capable of meeting the performance specification. Thus one can conclude that a similarly inflated packer inflated in a similar borehole diameter is capable of performance to the product specification.

- Inflation pressure – confirms that the final inflation pressure in the packer is acceptable and stable. This inflation pressure is related to a resultant contact pressure of the packer element against the borehole wall.

d. Data Review: Post-Inflation Hydraulic Test

- Pressure profile measurements - the presence of head gradients between adjacent zones is taken as evidence that the borehole annulus is not acting as a vertical conduit, and the packer seal is effective. It should be noted that an absence of detectible head gradients is inconclusive with respect to annulus seal performance, because a natural hydrostatic condition may be present.
- Dynamic single zone pressure tests (pulse tests, observation of natural head variations, observation of external head changes) - If such tests indicate different responses from adjacent zones (Example,

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

differing calculated transmissivity), this is evidence that the borehole annulus is not acting as a preferential pathway and the annulus seal is effective.

- Dynamic multi-zone tests (vertical interference tests) - Pressure responses are measured in a source zone and a response zone. Differences in response between source and response zone are evidence that the annulus is not acting as a preferential pathway and that the annulus seal is effective.

Responses to Specific Comments

1. Evaluation of the Grouted 10-inch and 5-inch Blank Casing (Page 3, Lines 22 - 30 and Page 4, Lines 1 - 3)

The Memo's evaluation of the grouted casing in monitoring well RHMW11 consists of very limited analysis as summarized in the statements: "Grout volumes during installation of both casings were consistent with calculated theoretical volumes" (Page 3, Lines 27 and 28) and "All evidence suggests that the cement-bentonite grout outside of the 10-inch casing and outside of the 5-inch inner casing successfully isolated deeper zones from the water from shallower zones within the borehole" (Page 4, Lines 1 through 3). The first statement of calculated theoretical volumes contradicts an earlier statement (Page 2, Lines 6 and 7) that states that "Both grout jobs were successful, with the actual volumes 6 used slightly exceeding the calculated theoretical volumes."

There are no grout calculations provided in the Memo to demonstrate that the injected grout volumes are consistent with or slightly exceeded calculated theoretical volumes. The BWS obtained the injected volumes from the boring log of RHMW11 and we calculated grout volumes using rudimentary assumptions. Our analysis indicates that the 550 gallons of grout injected at a depth of 165 feet is appreciably more than what theoretical calculations indicate is needed to fill the annulus with grout. To substantiate the claims of consistency between the injected grout volumes and the theoretical volumes, the report needs to include grout calculations along with justification of assumptions.

Among the assumptions that are important to calculating the amount of grout to successfully fill the annulus is how intervals of no core recovery affect the grouting process. An interval of no recovery could potentially represent a large void in the weathered or unweathered basalt where grout enters the basalt though a lava tube or a clinker zone. From a depth of 65 feet to 110 feet below ground surface (bgs) at RHMW11 there are six recorded no recovery intervals on the RHMW11 boring log. From a depth of 110 feet bgs to 165 feet bgs, there are ten recorded no recovery intervals. Many of these no recovery intervals are approximately 2 feet in total length, indicating substantial fractures or other void spaces. Among our concerns is that near the "no recovery" intervals in RHMW11, substantial grout was lost into large voids in the subsurface and an effective seal is not achieved between the well casing and the basalt. If this is the case, then the injected volumes may be substantially greater than the calculated theoretical volumes in order to effectively seal the annulus.

A common practice for checking whether an annulus has been properly grouted is to initiate a cement-bond log down a well casing. Cement-bond logs provide information on whether or not there is grout or voids against the outer diameter of the well casing. A cement-bond log is a regulatory requirement for wells in Texas that are required to be cased through useable groundwater. Given the large number of no-recovery zones in the log and the desire to seal and prevent hydraulic communication along the outside of well casing, a cement-bond log should be performed to demonstrate a successful grout of the annulus resulting in an effective seal. Without this information, how effective the steel casing in place at RHMW11 will always be in question.

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

Response:

See above responses to general comments.

At RHMW11, grout was placed in the annular space using a positive displacement methodology, where grout was pumped through a tremie pipe (positive displacement) in accordance with the Department of Land and Natural Resources "Hawaii Well Construction & Pump Installation Standards" and the Monitoring Well Installation Work Plan. Theoretical annular space volumes were calculated in the field prior to grouting the 10-inch and 5-inch conductor casings. The 10-inch conductor casing annular space theoretical volume was calculated as 382-gallons as compared to the 450-gallons of actual grout placed. The 5-inch conductor casing annular space theoretical volume was calculated as 434-gallons as compared to the 550-gallons of actual grout placed. These comparisons show an approximately 18- to 27-percent additional actual grout volume. The additional volume is associated with grout filling expected borehole irregularities (e.g., borehole widening across loose unconsolidated layers) and observed formation fractures. Review of the boring log across the 10-inch conductor casing depth (0-75 feet below ground surface [bgs]) shows unconsolidated materials and saprolite and the remaining depth (75-165 feet bgs) with only 5-inch casing shows saprolite. No-recovery zones from 0 to 165 feet bgs could be associated with clay blocking core recovery, washed-out fine material intervals, and/or compaction of unconsolidated materials. Fractures could also account for some no recovery zones within 0 to 165 feet bgs depth (several boulder sized competent rock zones observed), but are likely limited based on the predominately saprolitic nature of the material. No evidence of lava tubes were expected or observed within the saprolite and clinker zones were highly weathered. Grouting continued until visual presence of grout was observed at the surface.

2. Manufacturer's Packer Certification (Page 4, Lines 4 - 18)

We do not agree that a manufacturer certification is a line of evidence for having achieved a successful seal in the borehole. Such certification attests that the packer will inflate and should provide a seal but is not necessarily proof that a seal actually exists in the RHMW11 borehole. It would be appropriate if the packers were designed and tested to operate in boreholes that penetrate Hawaiian basalts like the Ko'olau Basalt. The Navy should clarify if Westbay has provided written assurances or recommendations for using their packers to isolate sampling zones in geological settings similar to the Ko'olau Basalt.

Response:

See above responses to general comments.

The Westbay System packers have been successfully used in open borehole applications in a variety of unfavorable geologic environments, including karst, coral reef deposits, active slope movements (landslides), basalts, and fractured rock near underground openings. A listing of successful employment of the Westbay System in a variety of geologic environments was provided as an attachment to the technical memorandum.

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

3. Packer Inflation Records (Page 4, Lines 19 - 37)

The Memo states that the packer inflation records indicate that all Westbay packers inflated normally and are providing effective annular seals between the monitoring zones (Page 4, Lines 36 and 37). The Memo notes that inflation plot for Packer No. 15 (Sheet 16, Attachment F) did not display a normal inflation pattern that includes a characteristic spike at the end (Page 4, Lines 30 through 35). This atypical response was attributed to an enlarged borehole diameter. Based on this information, the report statement "all of the Westbay packers inflated normally and are providing effective annual seals between the monitoring zones" is incorrect and contrary to the available information.

In order to support the statement of providing effective seals, additional information regarding the packing inflation and the caliper log should be discussed. The additional discussion should explain how that the abnormal inflation pattern at Packer No. 15 actually achieved a seal. Such a discussion should also cover the inflation plots for Packer No. 12 (Sheet 13, Attachment F); Packer No. 13 (Sheet 14, Attachment F); and, Packer No. 14 (Sheet 15, Attachment F). These Westbay packers show very similar inflation plots as Packer No. 15, but are not mentioned in this section of the memo and contradict the statement that "all" packers are providing effective seals.

Response:

See above responses to general comments.

Comment regarding packer seals in different diameters: Westbay tests of packer design and function include tests of performance while inflated to different diameters. The packer used in RHMW11 (Model 0235) is rated for operation in boreholes up to 6.3 inches diameter. The borehole diameters in RHMW11 where packers are positioned are less than the maximum rated diameter. The characteristic inflation pressure response expected for a nominal 5-inch diameter borehole is not observed and is not expected if the borehole diameter is larger. The important parameter is the stable inflation pressure measured at the end of the inflation process which was achieved, indicating that the packer element is supporting a measured internal pressure and is exerting a pressure on the borehole wall.

4. Water Level Elevations Profiles Measured in Different Zones

On Page 5, Line 13, Table 2 outlines which water level elevations are reported for the Navy identified 10 zones of RHMW11 (Zones 1, 2, 3, 4, 5, 6, 7, 8A, 8B, and 8C) during five separate measurement events (conducted in late November and late December 2017). On Memo Page 4, Lines 43 and 44, it is stated that the head differences between the zones (Table 2) supports the fact that the zones "are vertically isolated from one another". Head differences in Table 2 appear to suggest that there may in fact be only 5 separate "Zones" at RHMW11:

1. Zones 8C, 88, 8A

2. Zone 7

3. Zone 6

4. Zones 5,4,3, & 2

5. Zone 1

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

The BWS needs more information to be able to evaluate if indeed there are 10 distinct "Zones" at RHMW11. The Memo provides almost no interpretation of why these "Zones" were considered isolated relative to head differences.

The Memo states on Page 4, Line 44 that in the upper three zones, water levels are still stabilizing due to the extremely low hydraulic conductivity of the saprolite that they are completed in. We agree that one explanation for the slow response is a low conductivity of material open to the sampling interval. But, it may not be the only reason. A contributory factor to the long equilibration times could be leakage between packers and perched water draining through a leaky grout seal. To confirm the Memo's conclusion, calculations should be presented to show that the pressure-time response observed in the three upper zones can be explained based on theoretical calculated responses for a low permeability material. A starting point for this analysis is to perform the analysis using the range of hydraulic conductivity of 2.87E-09 centimeters per second (cm/s) to 3.00E-8 cm/s reported for the saprolite.

Response:

The presence of head differences across one or more packer seals, in combination with understanding of the expected formation hydraulic parameters, can serve as one line of evidence in support of the presence of an effective annulus seal. The term "zones" refers to discrete depth intervals isolated by packers that allow direct hydraulic communication with the aquifer. It is understood there could be natural hydraulic connection between different depth intervals at a regional scale. This appears to be the case for Westbay completion Zone 1 through Zone 5 based on similar (although still unique) hydraulic head values and are expected to represent the regional aquifer. Since Zones 1 to 5 are expected to be within the basalt that comprises the regional aquifer and thus be subject to very similar hydrogeologic conditions (head, transmissivity, vertical hydraulic conductivity), it is reasonable that the formation heads measured with the Westbay System are notably similar and do not provide definitive evidence for poor annulus or packer performance. At the borehole scale, unique head values are considered one line of evidence for effective isolation between zones. Head data from the Westbay completion indicate the presence of stable, repeatable vertical anisotropy in the regional aquifer and provide evidence of effective annulus seals. Further, the induced head changes from the Synoptic Pumping Events are associated with measurable differences in response of Zones 1 to 5 resulting from the induced gradients, also providing evidence of effective annulus seals.

The Navy will take into consideration the requested calculations to show that the pressure-time response observed in the three upper zones can be explained based on theoretical calculated responses for a low permeability material.

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

5. Temperature Profiles Measured in the Different Zones

The Memo states on Line 7, Page 5, "Monitoring of temperature in the zones at 30-minute intervals since December 2017 shows stable temperatures in each zone (Figure 3); each zone temperature are different from those of other zones. This provides additional evidence of isolation between zones."

BWS review of Figure 3 does not support the above statements. The upper Zone 6 and Zone 8 have essentially the same temperature measurements, which are consistently lower than those for Zone 7. Also, the meaning of the word "stable" is unclear. Our review of the temperature for Zone 4 indicates that over the entire period of record, the temperate is primarily decreasing and that stable temperatures have only been approximated during the last few weeks of the measurement record. This trend is also present but less apparent for Zone 5. Based on these observations, data from Zones BA, 88, BC, 6, 5, and 4 is contrary to the above statements. Moreover, some of these observations from these zones are consistent with the impacts associated with leaky Westbay packers.

Response:

The Navy does not agree that observations from zones 8A, 8B, 8C, 6, 5, and 4 are consistent with leaky Westbay packers. Please see the attached temperature profile, providing data through early March (additional two months than profile shown in Technical Memorandum). This updated figure provides further evidence that temperatures are stable. While Zones 6 and 8 are similar, temperatures within Zone 7 provide minor evidence that Zone 6 and 8 are not in hydraulic communication. Temperatures should be considered a minor line of evidence compared to the other major lines of evidence (i.e. packer inflation records, pneumatic testing, and water levels) for determining effectiveness of packer isolation.

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment

6. Pneumatic Testing of Multiple Zones within the Well (Page 5, Lines 16 - 33; Page 6, Lines 1 - 46, and Page 7, Lines 1 - 25)

This pneumatic testing discussion is insufficient to support the conclusion that the Westbay zones are isolated and that no leakage is occurring around the packer seals. The section is basically a data dump of pressure plots with little analysis and is presented with too little information to perform an independent analysis of the testing. To effectively demonstrate that the packers are working properly, the Memo needs to include an analysis for the theoretical response at the transducers for the case of a leaky packer AND a properly sealed packer. Because of the combination of the high hydraulic conductivity basalt and the small volumes of water used for testing, the BWS is concerned that there is effectively no substantial difference in the responses for the case of a perfectly sealed packer and a leaky packer. For the large number of graphs (Figures 6 through 25) to be useful to supporting the conclusion that all Westbay packers are working properly, the section needs to explain and demonstrate that the testing methodology used has been properly designed to identify if a packer is indeed leaking or not.

In the CWRM's solicitation memo, CWRM indicated concerns with two issues: 1) protection of the aquifer from well construction contamination; and, 2) how the Westbay system allows data to be collected and incorporated into the larger ground water monitoring network. CWRM believes that the grouting of the annular spaces around the conductor casing and internal 5-inch casing are sufficient to satisfy their first concern.

Based on our review, we found insufficient data to assure BWS that the aquifer is protected from well construction contamination because we question whether a sufficient amount of grout has been added to seal the annual spaces between the formation and the conductor casing. Incorporating the ground water data collected from the Westbay well into the database for the larger ground water monitoring network may be suspect because the zones identified by the Navy may not be isolated as the Navy Memo indicates.

Response:

- See above responses to general comments.
- The pneumatic test was conducted using compressed gas and not small volumes of water as indicated in the comment. As noted in the technical memorandum, pneumatic testing in higher permeability deeper zones was performed at pressures of 10, 20 and 40 psi (approximately 2.31 feet of equivalent head per psi), and no response was observed in adjacent zones. In the much lower permeability shallower zones (Zones 6 – 8), pneumatic testing was performed at pressures between 5 and 15 psi and no response was observed in adjacent zones. The absence of response in adjacent zones provides another line of evidence that the zones are effectively sealed.
- Values of hydraulic conductivity/transmissivity calculated from test results are consistent with expected formation values, indicating the packer seals are effective.
- Comparison of source zone and response zone performance shows notable difference, consistent with expected values of formation vertical hydraulic conductivity.
- Comment on 'perfectly sealed packer vs leaky packer': The test response evaluation is constrained by the formation hydraulic parameters. In an open borehole environment, test results are evaluated to assess the presence of an effective annulus seal, with the understanding that the formation hydraulic performance constrains such interpretation. This constraint does not diminish the value of such tests to provide another independent line of evidence.

Project Title: Honolulu Board of Water Supply (BWS) Comments on the Department of the Navy (Navy) Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii, February 9, 2018 completed under Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7
Letter to: Jeffrey T. Pearson, State of Hawai'i Department of Land and Natural Resources, Commission on Water Resources Management
Reviewer: Ernest Y. W. Lau, City and County of Honolulu Board of Water Supply
Date: April 10, 2018

Comment references:

Commission on Water Resources Management (CWRM). 2018. Red Hill Monitor Well 11 (State Well No. 3-2253-011). Solicitation Letter to Mr. Ernest Y.W. Lau, P.E. from Mr. Jeffrey T. Pearson, P.E. March 27.

Department of the Navy (Navy). 2018. Technical Memorandum: Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility (RHBFSF) Joint Base Pearl Harbor-Hickam, Oahu, Hawaii. February 9.